Thermal influence of the Lake Inawashiro on the LocalClimate in Summer Daytime

Thermal Influence of the Lake Inawashiro on the Local-Climate in Summer Daytime

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In a previous paper (1967), the author reported on the air temperature distribution, in summer daytime, influenced by the lake Inawashiro, Fukushima prefecture, showing that it was cooler on the leeside shore than on the windward shore by 2.8°C~4.5°C under the clear weather, while the air temperature over the lake was widely uniform under the windless and cloudy weather. From the view-point of heat-budget, however, the difference between both shores in former case is too large. And the author's observations were tried again on July 10th, 1968, in order to compare the air temperature on one shore with that on the other.

I Observations

On July 10th the clear weather continued until 14:00 on the south shore, while on the north shore it lasted until 15:00, after which the cloudy weather prevailed all over the lake. On the north shore, the northerly or northwesterly wind (0.8~2.3 m/sec) was blowing from the land side during the clear weather, but the southerly wind, blowing from the lake side, began to alternate with the northwesterly at 15:15. On the south shore, on the other hand, the southerly wind from the land side alternated at 14:15 with the northerly (1.3~2.5m/sec) continuously blowing from the lake surface until that time.

That is because a southerly wind area with cloudy weather expanded to the north over the lake. After that, on the south shore, a rainy weather came to move toward the north at about 16:15. Such a weather change is due to a front locally developed in this region. It was caused by the local front, approaching the lake, that the N~W wind had prevailed in place of the lake-breeze which would develop during the sunny hours around noon. Fig. 2 shows the diurnal variation of insolation at Okinajima (see Fig. 1) near the north shore.

Air temperature observations using the thermister were made every fifteen minutes, during the hours between 11:00 and 16:00, at the following four locations (see Fig. 1).

H. Shitara (1967); Air Temperature in Summer on and around the Lake Inawashiro, Fukushima prefecture Sci. Rep. Tohoku Univ. 7th Ser. (Geogr.) No. 16, pp 67–84

	locations	levels of observations (height in meters)
(A)	Nagahama on the north shore	1.5, 3.0, 4.0, 5.0
(B)	On a boat located 200 meters south of the north shore	0.1, 0.4, 1.0, 3.0
(C)	On a boat located 80~300 meters north of the south shore	1.5
(D)	Funazu on the south shore	0.1, 0.4, 1.5, 3.0, 4.0, 5.0

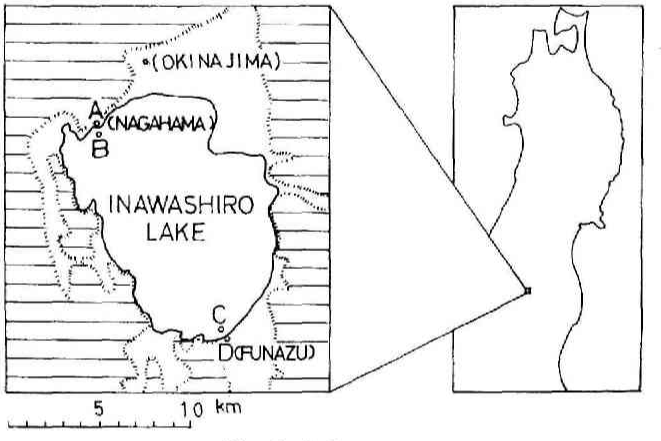

Fig. 1 Index map

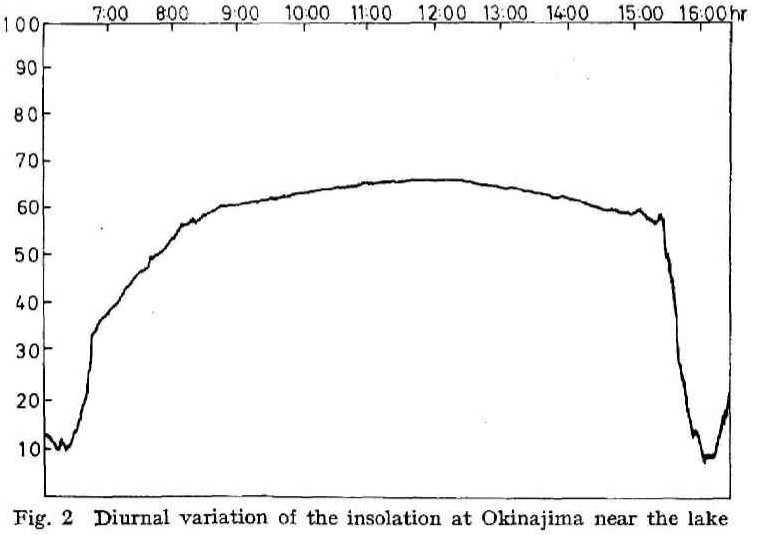

Fig. 2 Diurnal variation of the insolation at Okinajima near the lake

Here, the levels of air temperature observations were limited as above by the number of thermometers. The wind directions and velocities were observed at the locations A and D.

II Thermal influence of the lake surface upon the 1.5 m-level air temperature

When the N～W wind was prevailing under the clear weather, it was cooler on the south shore, being in the leeward from the lake, than on the north shore free from the air on the lake. And the air temperature difference, at the 1.5 m-level, between both shores most frequently appeared within the interval of 3.5°～4.0°C, which almost coincides with that noted in the previous paper (1967). The comparative coolness on the leeside shore is clearly due to the thermal influence of all the surface of the lake, the water temperature of which was lower than the air temperature on the north shore by 7.0°～9.0°C.

However, the thermal influence of the water surface seems to be negligible in the leeside area of the lake, while it is effective in the windward area of the lake,

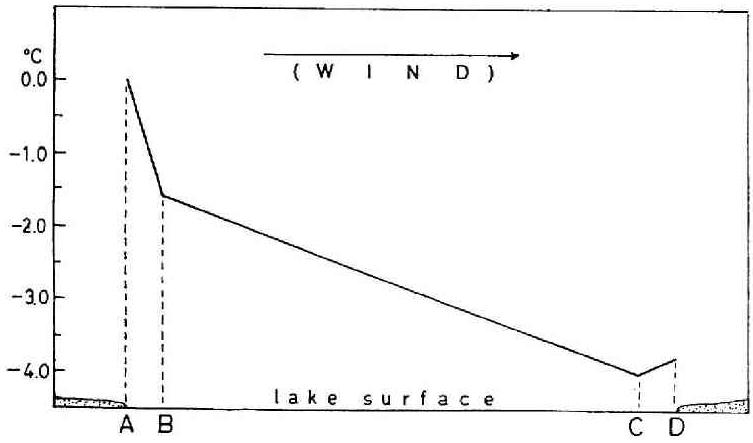

Fig. 3 Brief profile of the air temperature at 1.5m-level on the lake

because the air temperature difference between Location A on the windward shore and Location B, 200 meters distance leeward on the lake, are within the interval of 1.2°～3.0°C, the average value of which is 1,7°C, on the other hand, the difference between Location C on the lake and Location D on the leeside shore is little, the average value of which is 0.3°C (Fig. 3).

III Influence of meteorological condition upon 1.5 m-level air temperature

The temperature difference between both shores lasted while the N～W wind prevailed under the clear weather. But such relations in air temperature disappeared when southerly wind from the lake side began to blow on the north shore at 15:15. At this time, there was a sudden drop (about 4.0°C) of air temperature, which value means the temperature difference between the air on the land and on the lake, and the value almost coincides with the above mentioned temperature difference between the windward shore and the leeside shore.

An hour earlier, it turned cloudy on the south shore, but the air temperature change disappeared there. It means that the weather change from clear to cloudy weather has little influence upon the thermal feature of the air on the lake. On the contrary, there is a noticeable thermal influence of such a weather change upon the air on the land, because the air temperature at the south shore rose a little when the air on the land surface began to flow onto the shore at 14:30 under the cloudy weather, though great rise would be expected under a clear weather.

IV Vertical gradient of air temperature near the surface

As above mentioned, the air on the land receiving the insolation is far warmer than the air on the lake or the air on the land without the insolation. This phenomenon seems to be related to the heating effect of the underlying surface. This will be supported by the vertical gradient of the air temperature.

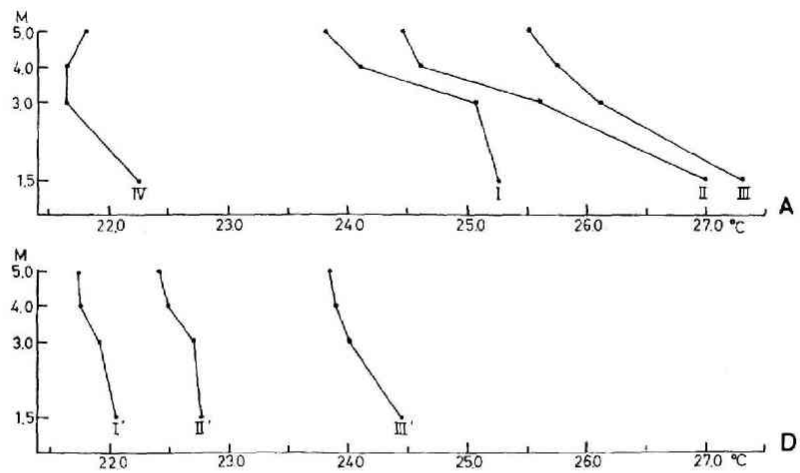

Fig. 4 Vertical profiles of the air temperature at both the shores,north(A) and south(D)
I I'; 11:00～11:45, II II'; 12:00～12:45, III III'; 14:30～15:15, VI; 15:30～16:15

When the N~W wind is prevailing under the clear weather, the air temperature difference of every fifteen minutes between both levels, 1.5 m and 5.0 m, is usually above 1.0°C on north shore with the average value of 2.2°C. But the difference suddenly becomes smaller, being about 0.4°C, when the air on the lake begins to flow on the north shore. On the south shore a little difference is kept under the northerly wind from the lake surface, with the average value of 0.3°C.

Fig. 4 shows several vertical profiles at both shores. These profiles represent that the temperature of the air flowing from the land surface under the clear weather is higher, especially on the level near the ground, though the warmer layer near the underlying surface disappears on the lake or under the cloudy weather.

V Thermal influence of the lake upon the micro-climate

It is suggested by the average profile (11:00~14:15) under the clear weather that the micro-climatic air temperature contrast between the windward and the leeside shores continues while the N~W wind is prevailing over the lake (Fig. 5).

The "incoming radiation type" in that profile observed on the north shore (A) disappeared not only on the south shore (D) but at the location (B) on the lake. It is noted that the high air temperature of the lowest layer formed on the land surface will disappear while the air flows on the water surface for a distance of only about 200 meters. Since the level of 1.5 m is in the layer, the air temperature at 1.5 m-level ought to be affected by the vertical micro-climatic feature based on the heating effect of the underlying surface.

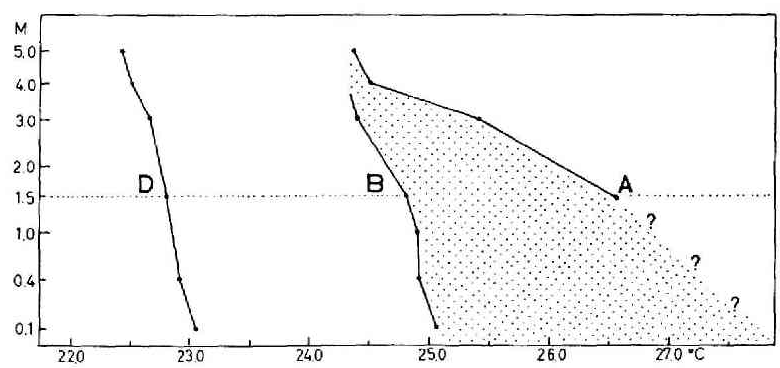

Fig. 5 Average vertical profiles of the air temperature under the northely wind

VI Thermal influence of the lake upon the local-climate

That such a micro-climatic feature as a small water surface easily weaken, should be excepted from a local-climatological investigation in the scale of above

10 kilometers. Accordingly, the thermal influence of the lake upon the local-climate will be detected by comparing the air temperature at the leeside location (D) with that at the windward location (B) which becomes free from the micro-climatic feature formed by the land surface.

The air temperature difference between both locations is about 2.0°C at every level below 5.0 meters, and this value should be estimated as the air temperature difference due to the thermal influence of the lake, in the scale of local-climate.

VII Air temperature profile in the plain near the lake shore

In the author's previous paper (1967), it was represented on 1.5 m-level, that the regionally homogeneous air temperature was observed in the plain free from the lake breeze, while the difference in air temperature of the shore and a location in the plain was comparatively large under the lake breeze. The air temperature at 1.5 m-level, as mentioned above, is subject not only to local climatic feature but to the micro-climatic influence from the underlying surface. And on the ground near the leeside shore, the air temperature at 1.5 m-level can be increased at least by micro-climatic influence alone of the land surface (Fig. 6). Since the land surface receiving a strong insolation easily produces a micro-climatic warmer layer in it, the horizontal gradient of air temperature mentioned above will be formed within a little distance leeward.

Based on such a view-point, the observation was carried out on the horizontal air temperature at 1.5 m-level in micro-scale. The profile in the plain near the leeside shore is shown in Fig. 7. In the profile corresponding to the surface

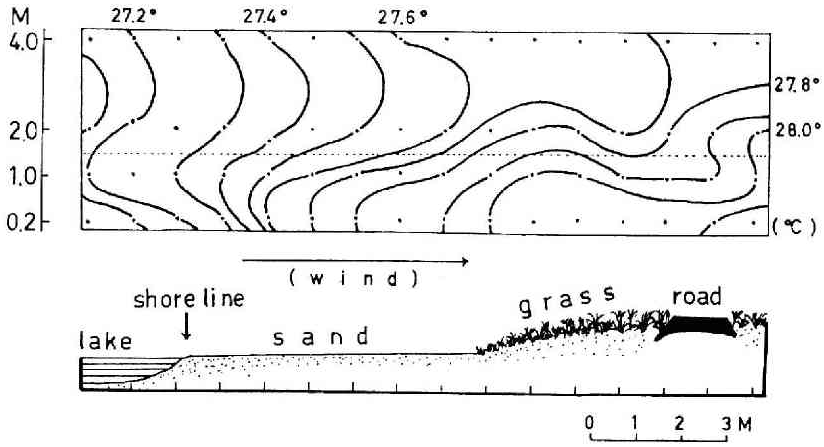

Fig. 6 Micro-climatic air temperature section on the shore under the lake breeze (11:30 July 7th 1963)

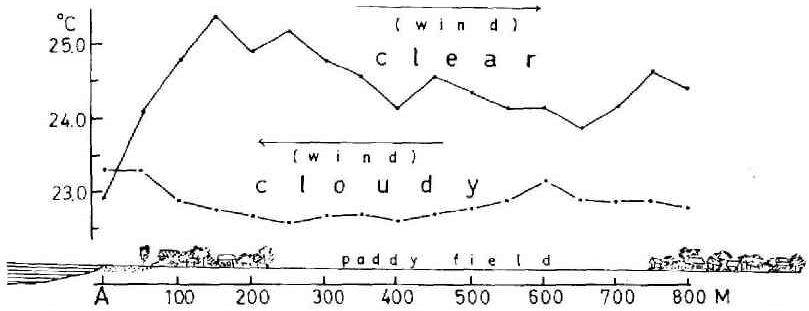

Fig. 7 Air temperature change at 1.5 m-level on the ground according to the distance from the south shore

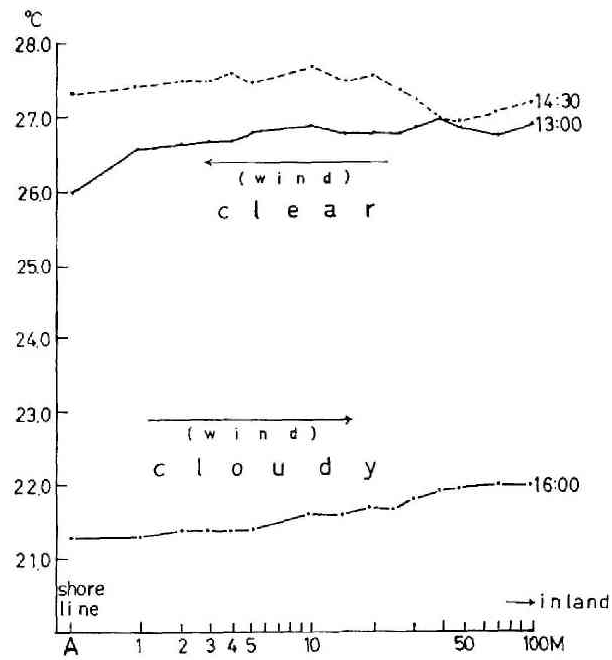

Fig. 8 Air temperature change at 1.5m-level on the ground according to the distance from the north shore

condition when it is clear, the most noticeable change of temperature can be noted nearest to the shore. Here, the temperature difference between the shore-line and the paddy field 500 meters distamt from the shore is about 1.0°C. On the other hand, such a difference is observed neither in the plain near the windward shore (Fig. 8) even if it is clear, nor in the plain near the leeside shore under the cloudy weather (Fig. 7).

VII Conclusion

The results of the air temperature observations on and around the lake Inawashiro in the summer daytime can be summarized as follows;

1) The air temperature difference at 1.5 m-level between the windward shore and the leeside shore is larger when the wind is blowing across the lake under the clear weather.

2) When the air-flow from the lake surface alternates with that from the inland, there is a sudden drop in the air temperature.

3) Horizontal air temperature change on the lake in accordance with the distance from the windward shore is large in the windward area, while that is small in the leeside area.

4) Vertical air temperature gradient (1.5 m$\sim$5.0 m) under the clear weather is far stronger on the windward shore than on the leeside shore.

5) Under the clear weather, the characteristics with the incoming type in micro-climate is observed in the vertical air temperature profile blow 3.0 m-level, and it disappears at a location 200 meters distant from the windward shore, and appears again in the plain near the leeside shore.

6) The air temperature difference, between the location on the lake near the windward shore free from the micro-climate on the ground and the leeside shore, is about 2.0°C, which is estimated as the thermal influence of the lake surface upon the local-climate, within the limits of these observations.